Goals and Reality of Risk Management: Lessons Learned from Space Program Execution

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Introduction

- This presentation discusses objectives of post-award Risk Management, as formulated in current National Security Space (DoD / NRO) acquisition and mission assurance policies
- Reviews some types of RM application in past and present NSS systems acquisition programs
- Comments on what was learned about the strengths and weaknesses of observed approaches to RM
- Comments and offers some suggestions on some key current RM implementation issues

Definitions of Risk and Risk Management

Definitions of Risk and RM in acquisition context (from DoD Risk Management Guide):

Risk is a measure of the inability to achieve overall program objectives within defined cost, schedule, and technical constraints and has two components: (1) the probability of failing to achieve a particular outcome and (2) the consequences of failing to achieve that outcome.

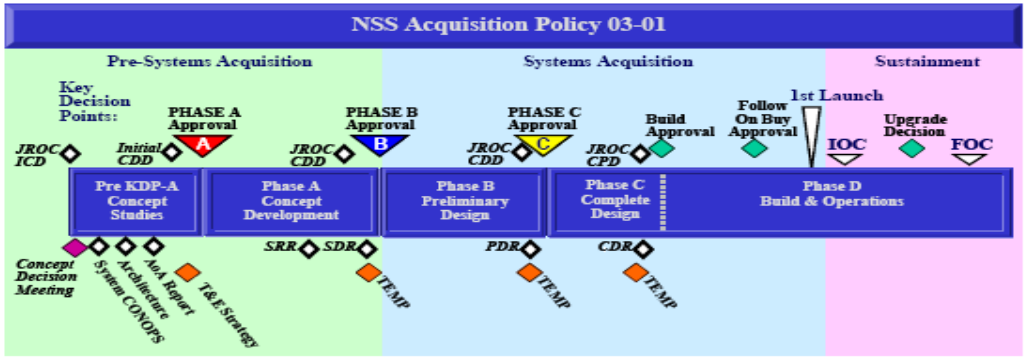
Risk Management is the act or practice of controlling risk. It includes risk planning, assessing risk areas, developing risk-handling options, monitoring risks to determine how risks have changed, and documenting the overall risk management program.

NSS Policy Concerning Risk Management

Acquisition Context

– **National Security Space Acquisition Policy 03-01 (NSS-03-01) identifies RM use in the context of NSS program acquisition lifecycle**

- **Risk reviews to be carried out as input to each of the acquisition "KDPs" ("Key Decision Points"), within the Independent Program Assessment (IPA) and Independent Cost Assessment (ICA) processes**
- **Successful completion of these independent reviews requires the existence and execution of a Risk Management Plan by all NSS programs**



Mission Assurance / System Safety Context

– **Air Force and SMC OSS&E directives (AFI 63-1201, SMCI 63-1201) establish requirements and guidance for mission-assurance and safety oriented use of RM**

NSS-03-1 RM References

The IPA (Independent Program Assessment) Team is charged with reviewing and independently assessing, among other program activities, the performance and schedule risk issues of a given space program

- **"The focus of the IPA should be on the identification and evaluation of all elements of program risk. In essence, the IPA's job is to determine if the SPD/PM has properly identified and quantified program risk areas, and then assess whether adequate risk mitigation plans are in place."**

The ICA (Independent Cost Assessment) Team is charged with reviewing and assessing cost issues, and executing an independent cost-risk analysis of a given space program

- **"The ICAT … shall:**
  - **Provide quantitative assessments of the risk in the cost estimates.**
  - **…**
  - **… consider cost implications of the IPAT's assessments of the program's schedule and technical risks, and may include the results in its cost-risk assessments. "**

Intended Objectives of RM Execution vs. Application Experience

- **RM intended purpose in the programmatic context is:**
  - **To provide a common ground for evaluation and assessment of technical, cost and schedule risk issues that may affect a program**
  - **To serve as a decision-support process that provides the program managers with:**
    - Assessments produced by the program technical experts
    - Decision criteria that utilize such assessment to identify program actions to be executed
- **More limited uses of RM have been common in most programmatic environments in actual NSS program experience:**
  - **Compliance with mandated requirements**
  - **Generation of risk information for external program reviews**
  - **Communication of risk across organizational branches**

Lessons Learned from Application Experience

- **Lessons learned can be roughly grouped according to the experience of RM application in three separate historical time-frames:**
  1. **Pre-acquisition-reform era applications**
  2. **Acquisition-reform era applications**
  3. **Current applications**

Pre-Acquisition-Reform RM Experience: Heritage LV Programs

1. RM applied on an "ad-hoc" basis
   - Launch verification and certification process believed to be an effective "risk management" process from the mission assurance point of view
   - Plenty of resources to deal with "issues" after they appeared
2. Limited amount of preventive risk identification
   - Hardware pedigree and non-compliance report reviews main instrument to uncover potential issues
3. In-depth risk analysis of clearly threatening issues
   - Issues recognized as potentially mission-threatening were worked deterministically for "root-cause" identification and probabilistically for risk-reduction to "acceptable level"
     - Rather stringent mission risk criteria for "single issue contribution" (e.g. < ~ 3 in 1000 at 95% confidence) often (but not always) used for launch / no-launch decisions

Lessons Learned from RM Use in Heritage LV Programs

- **Absence of a wide-scope RM process can be a problem but also an advantage**
  - Quantitative risk assessment was applied very selectively
  - Potential for inconsistency when making decisions based on quantitative risk criteria for a few issues and on qualitative judgment for others
    - Might a more uniform application of RM criteria have had preventive effects on one or two of the few launch failures that occurred?
  - But when applied, risk assessment was carried out in depth and with adequate allocation of time and resources to generate high-quality output
    - Many examples of application for assessment of launch vs. rework options resulting from the potential presence of defective parts / components in a vehicle set for launch

Acquisition-Reform-Era RM Use: the Advent of Formalized RM Processes

- **Acquisition-Reform era saw the establishment of formally documented RM processes**
  - **RM Guide for DoD Acquisitions**
  - **NASA RM Guide**

- **Flip-side of process emphasis was trend towards marginal level of depth in technical assessment aspects of RM activities**
  - **Effect aggravated by:**
    - **The diminished level of technical assessment resources on Government / FFRDC side of acquisition process**
    - **Over-reliance on Contractor risk assessment and risk management processes**

Lessons Learned from Acquisition-Reform Era RM Use

- **Routinely accepted RM processes introduced biases in assessment of risk issues**
  - **Relatively common for "standard" risk matrices to introduce inconsistencies in the relative assessment of "mission" versus "programmatic" risk**

Likelihood of Occurence \ Severity of Consequence	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Legend:Red = High Risk
Yellow = Moderate Risk
Green = Low Risk

Level	What is the likelihood that the event/situation will occur?
1	Remote (0-20%)
2	Unlikely (>20-40%)
3	Likely (>40-60%)
4	Highly Likely (>60-80%)
5	Near Certain to Certain (>80-100%)

Level	Given the risk is realized, what is the magnitude of the impact (technical, schedule, cost) on the program?		
	Technical	Schedule	Cost
1	Minimal or no impact	Minimal or no impact	<$100K
2	Some system req may be impacted; system performance degraded	Able to meet need dates; additional resources required	$100K to $500K
3	Some system req may not be met; a particular feature impacted	Minor slip in key milestones; not able to meet need dates	$500K to $2M
4	Key functional requirement(s) not met.	Major slip in key milestone or critical path impacted	$2M to $10M
5	Unacceptable	Can't achieve key team or major program milestone	> $10M

RM Matrix Set-up / Use Issues

Example 1: Problems with "linear binning" of likelihood / probability

- **Typical 5 x 5 risk matrix uses linear breakdown of probability dimension**

Level	What is the likelihood that the event/situation will occur?
1	Remote (0-20%)
2	Unlikely (>20-40%)
3	Likely (>40-60%)
4	Highly Likely (>60-80%)
5	Near Certain to Certain (>80-100%)

- **Events that carry high severity of consequences with probability as high as 15 or 20% are ranked in the same risk category as events with same consequence severity but much lower probability, e.g. in the order of 1 / 1000**
  - **This is inappropriate when applied to rank mission risk items, or to compare the latter to programmatic (cost / schedule) risks**

RM Matrix Issues (cont.)

Example 2: Problems with relative calibration of consequence-severity bins

- **If risk of different consequence nature are ranked together, the impact severity levels of the associated scales must be explicitly calibrated to be inter-consistent**

Level	Given the risk is realized, what is the magnitude of the impact (technical, schedule, cost) on the program?		
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- **If applied to typical NSS program with high mission cost / value, equivalence of mission loss with cost impacts as low as $10M does not provide a good inter-calibration of consequence scales**

Effect of RM Matrix Issues

- **Program Case Study: Independent review of original assessment found systemic underestimation of performance risk items**

			After Scale Calibration					Original Assessment	
ID	RiskTitle	Consq Cat	L	Conseq	Color	Rank		Color	Rank
73	[redacted]	Performance	0.9	0.25	Red	3		Red	3
108		Performance	0.7	0.25	Red	4		Red	4
1		Performance	0.5	0.5	Red	1		Red	1
129		Performance	0.5	0.5	Red	2		Red	2
2		Performance	0.5	0.25	Red	5		Yellow	5
3		Performance	0.7	0.15	Red	9		Yellow	9
24		Performance	0.5	0.25	Red	6		Yellow	6
110		Performance	0.7	0.15	Red	10		Yellow	10
5		Performance	0.5	0.15	Red	13		Yellow	13
115		Performance	0.5	0.15	Red	17		Yellow	25
117		Performance	0.5	0.15	Red	18		Yellow	26
7		Performance	0.3	0.25	Red	14		Yellow	31
20		Performance	0.7	0.1	Red	20		Yellow	33
25		Performance	0.7	0.1	Red	21		Yellow	34
29		Performance	0.3	0.25	Red	15		Yellow	35
8		Performance	0.3	0.15	Yellow	28		Yellow	39
9		Performance	0.3	0.15	Yellow	29		Yellow	40
15		Performance	0.5	0.1	Red	24		Yellow	41
16		Performance	0.3	0.15	Yellow	30		Yellow	42
22		Performance	0.5	0.1	Red	25		Yellow	45
131		Performance	0.3	0.15	Yellow	31		Yellow	49
28		Performance	0.1	0.5	Red	26		Yellow	50
23		Performance	0.1	0.25	Yellow	44		Green	53
30		Performance	0.3	0.1	Yellow	42		Green	54
31		Performance	0.3	0.1	Yellow	43		Green	55
13		Performance	0.1	0.15	Yellow	47		Green	56
14		Performance	0.1	0.05	Yellow	49		Green	60

Effect of RM Matrix Issues (cont.)

- **Program Case Study: Original cost risk results were systemically overestimated with respect to re-calibrated estimations**

			After Scale Calibration					Original Assessment	
ID	RiskTitle	Consq Cat	L	Conseq	Color	Rank		Color	Rank
32	[redacted]	Cost	0.5	0.000222	Green	61		Yellow	21
33	[redacted]	Cost	0.5	0.001002	Green	55		Yellow	22
19	[redacted]	Cost	0.3	0.0045	Green	54		Yellow	32
74	[redacted]	Cost	0.7	0.000222	Green	58		Yellow	36
18	[redacted]	Cost	0.5	0.000222	Green	59		Yellow	43
21	[redacted]	Cost	0.5	0.000222	Green	60		Yellow	44
78	[redacted]	Cost	0.3	0.001002	Green	57		Yellow	47
17	[redacted]	Cost	0.3	0.001002	Green	56		Green	59
77	[redacted]	Cost	0.1	0.000048	Green	62		Green	62

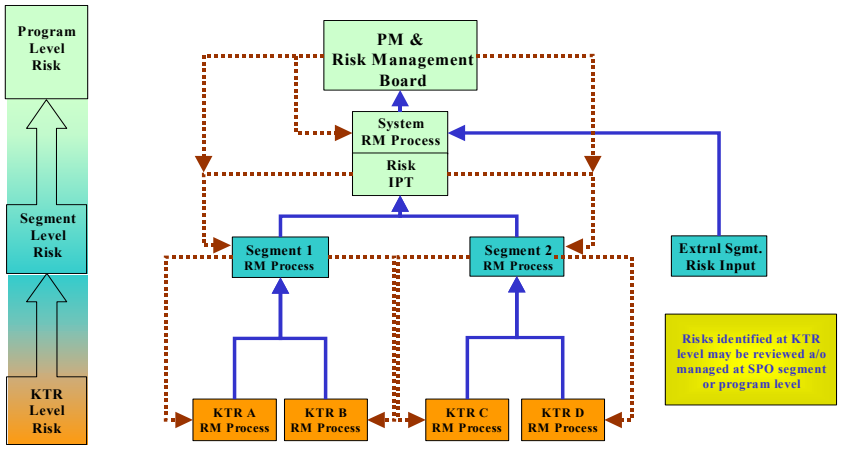
Post-Acquisition-Reform Era RM Use

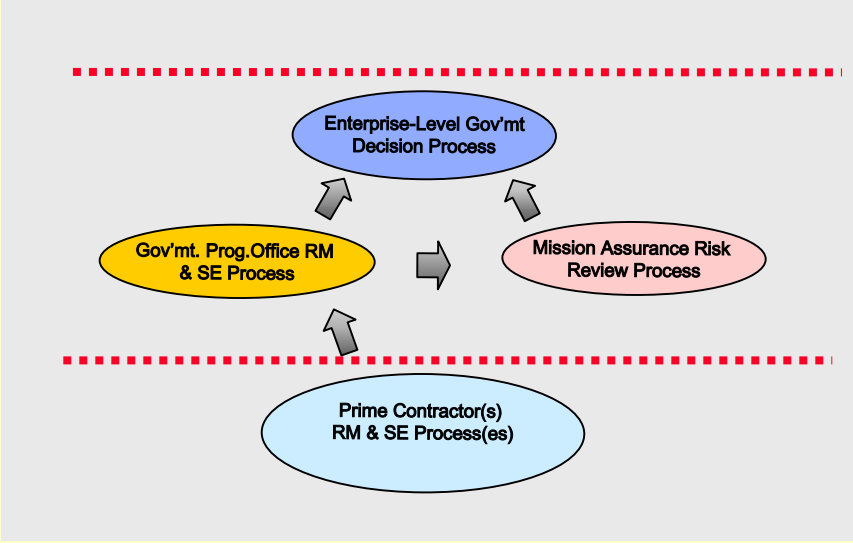
- **Today's programs are slowly absorbing lessons from earlier programmatic applications**
- **Two interrelated issues are at the top of the list as potential discriminators for RM implementation success:**
  - **Hierarchical organization of RM processes in complex, multi-level programs**
  - **Integration of RM process with programmatic decision processes and with the other engineering processes that are at the core of NSS acquisitions**

Lessons Learned: Hierarchical RM Processes

- **Multi-level programs require the integration of several layers of RA and RM**
  - **Relative relevance of risk issues varies with successive program levels at which they can be addressed / handled**
  - **"One-fits-all" qualitative rating scheme is usually inadequate to accommodate need for recalibration of risks as these get elevated to higher levels of visibility / consideration**

Examples of RM Hierarchical Processes



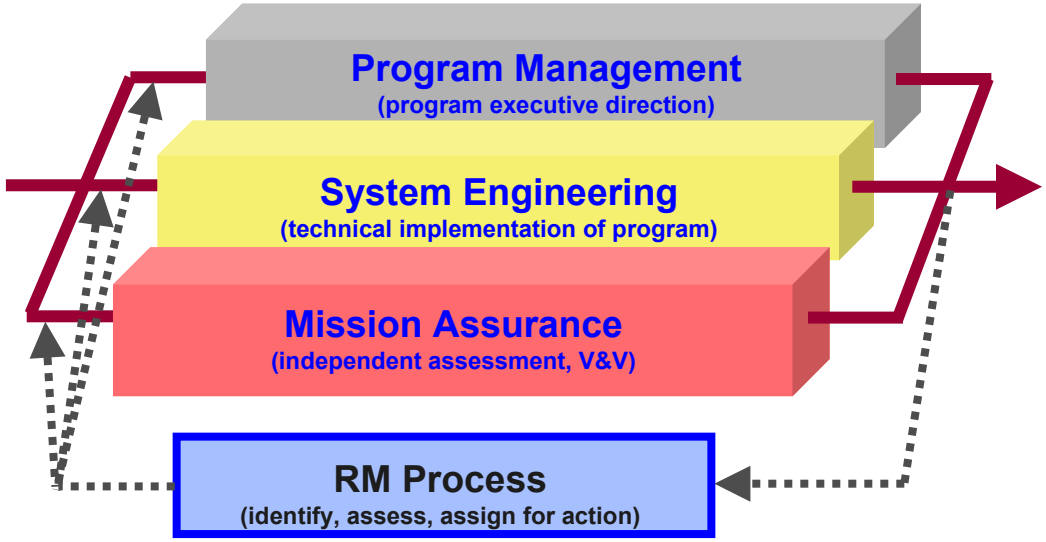


Lessons Learned: RM Insertion in Program Decision Process

- **Essentially a case of "Use it or lose it"**
- **RM activities default to perfunctory mode when a program does not utilize RM process and information in decisions for adjudication of priorities and resources**
- **PM can set the standard for risk-informed decisions supported by appropriate levels of assessment and analysis, by requiring the integration of RM with the program mainstream management and systems engineering processes**

RM in Relation to NSS Acquisition Management and Engineering Processes

- **Based on past "lessons-learned," recommendation for effective RM execution in NSS acquisitions is to seek a balance between "programmatic" and "technical" use**
  - **In pre-acquisition reform era, RA/RM was mostly used as a mission assurance tool**
  - **In acquisition reform era, RM was primarily viewed as being a program management / communication tool**
- **RM can have a unique balancing role as the feedback mechanisms that joins together the acquisition pillars of Program Management, Systems Engineering and Mission Assurance**



Adjusting and Balancing Uses of RM

For successful use of RM across the spectrum of Program Management, Systems Engineering and Mission Assurance issues, flexibility is the key:

- Use of RM in an integrated context may require deciding whether a risk is to be viewed, at a given program stage, from a specific point of view
  - **Program Management perspective:**
    - Assessment mostly focused on macro-level cost/schedule implications
    - Emphasis on early warning for serious issues that may require high-level intervention and programmatic action
  - **Systems Engineering perspective**
    - Identification / assessment of technical feasibility and interface issues
    - Emphasis on identification of alternative architecture / design / engineering / programmatic solutions
  - **Mission Assurance perspective**
    - "As good as possible" assessment of risk items
    - Rigorous identification and evaluation of mission success, minimum risk alternatives
- Risk Assessment and Risk Management execution needs adjustment as program focus evolves from early lifecycle perspective towards deployment phase mission success objectives
  - **"First-order" approach used in categorization and assessment of program development risks is often inadequate in estimation of mission risk**
    - Recall example on use of linear likelihood binning: 15% probability of a serious schedule or cost impact may seem ok if impact is years away, but same probability is unacceptable if possible impact is on mission success and only weeks ahead

In Closing: What Direction for the Future?

- **A flexible Risk Management process implemented within the context of a program-wide Systems Engineering framework can support Program Management, Systems Engineering and Mission Assurance functions in a large space program**
- **Requires a number of features and attributes that have been elusive to implement in the past**
  1. **Active participation of Government stakeholders'**
  2. **Flexible but centrally normalized execution, with technical consistency validated by independent reviews**
     - **Well coordinated "risk filter" mechanisms to sort items for assessment under a primary risk perspective (i.e., PM, SE and/or MA), prioritize them, and assign assessment and handling responsibilities**
     - **Effective risk-scales calibration to avoid gross inconsistencies in assessment**
- **PMs' use of RM / RA as integral element of program management and system engineering functions is crucial to generation of objective and substantive content by the RM and RA processes**